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BULLETIN 318 JUNE, 1935

Removal of Spray Residues From Apples

APPLYING A COVER SPRAY IN EXPERIMENT ORCHARD NO. 2, AT STATE COLLEGE

IMPERIAL MYCOLOGICAL
10 OCT. 1935
INSTITUTE

THE PENNSYLVANIA STATE COLLEGE
SCHOOL OF AGRICULTURE AND EXPERIMENT STATION
STATE COLLEGE, PENNSYLVANIA

Summary and Recommendations

Residues on Pennsylvania apples in 1934 exceeded the legal tolerances in many cases. For 1935, these tolerances have been set by the Federal Government at .018 grain of lead, and .01 grain of arsenic trioxide per pound of fruit. This means that growers who must spray in July or August to control codling moth or maggot will almost certainly be faced with the necessity for washing the fruit in order to market it legally.

Over 500 samples of Pennsylvania apples were subjected to various experimental washing treatments in 1934. It was found that the satisfactory removal of lead presented a greater problem than that of arsenic, and that certain conclusions based upon studies of the arsenic removal alone do not meet present requirements. Results of these tests, as reported in this bulletin, appear to justify the following recommendations:

Spray residues difficult to remove should be avoided by following the spraying recommendations given through the office of each County Agricultural Agent.

Fruit should be washed at harvest, not as taken from storage.

A home-made flotation type washer can be recommended for Pennsylvania conditions, especially for small quantities of fruit, but the more expensive under-brush machines are somewhat more efficient.

Hydrochloric acid, at 1.0 to 2.0 per cent concentration by weight (3 to 6 gals. 20° B. acid per 100 gals.), should be used to secure maximum residue removal without injury to the fruit. One minute exposure to the acid in a flotation machine should be satisfactory in most cases.

The necessary concentration of acid depends on the amount of lead to be removed, the spray mixture employed, and the variety of fruit. A wash containing 1.5 per cent acid should meet most needs in 1935.

The acid solution should be tested at frequent intervals and restored to the desired strength, and should be changed completely after each 1,000 bushels.

Sufficient quantities of rinse water (2 to 3 gallons per bushel of fruit) should be used to remove all traces of acid from the washed fruit.

The keeping quality of the fruit is not impaired by packing the apples wet, but the use of a drier facilitates grading and packing.

The addition of wetting agents or salt to the hydrochloric acid solution has given no consistent benefit in the removal of lead from apples sprayed according to Pennsylvania recommendations. The use of wetting agents may be justified in other states where lead arsenate has been combined with or followed by mineral oil sprays.

If apples are not cleaned satisfactorily with cold 2 per cent hydrochloric acid solution, it is recommended that the temperature of the acid be maintained at 100° F., through the use of electric immersion heaters, the introduction of live steam, or of steam coils.

Only when hydrochloric acid at 100° F. fails to give satisfactory residue removal is it recommended that the machinery be slowed down to give 1½ to 2 minutes exposure of the fruit to the acid solution.

Removal of Spray Residues From Apples

Donald E. H. Frear and Harlan N. Worthley

The possible poisonous effects of lead and arsenic on the surface of fruit sprayed with lead arsenate have been discussed for many years. As early as 1895, the toxic effects of spray residues were considered, particularly lead arsenate, which was just coming into use as an insecticide.

The amount of arsenic which may be present in food materials was limited by the food and drugs act of 1906 to 0.01 of a grain of arsenic trioxide per pound. In some sections of the country it then became difficult to control infestations of the codling moth and still keep the amount of arsenic remaining on the fruit below the Federal tolerance limit. In 1926, investigations were begun in several states on the possibility of washing the fruit to remove the high residues present.

In Pennsylvania, lighter codling moth infestations have prevailed until recent years; consequently fewer spray applications have been necessary. Relatively small amounts of spray residues remained on the fruit at harvest; hence the problem of residue removal was not important in this state. About 1930, however, it became apparent that the codling moth population was increasing rapidly and that it would be necessary to increase the number of spray applications in order to produce clean fruit. The situation became acute in 1933, when the Federal authorities placed a limit on the amount of lead as well as of arsenic. In 1933, many Pennsylvania orchardists sprayed more lightly than the codling moth infestation demanded, in an attempt to meet the legal residue limits without washing. This permitted the insects to increase at an alarming rate. In 1934, a large number of growers were faced with the necessity of washing their fruit, since the number of necessary spray applications left a residue of arsenic and lead several times the legal tolerance, which then was .019 grain of lead per pound of fruit and .01 grain of arsenic per pound of fruit. The legal tolerances for 1935 have been set at .018 grain of lead per pound of fruit and .01 grain of arsenic per pound of fruit. To meet these tolerances, fruit washing will be necessary for those growers who face the necessity of spraying in July or August for the control of codling moth or apple maggot.

In order to answer some of the most pressing questions on washing methods under Pennsylvania conditions, experiments were begun at State College and in Adams County during 1934.

How Spray Residues May Be Reduced

Any method, mechanical or chemical, which will remove enough spray residue without injurying the fruit is satisfactory. Two main methods have been suggested: dry brushing or wiping, and washing.

[1] Publication authorized May 27, 1935.

Dry Brushing.—Dry brushing is used extensively in Pennsylvania for the removal of peach fuzz. Attempts have been made to use the brushing machines for removing spray residues from apples. They are quite unsatisfactory for this purpose, as is shown in Table 1. The brushes become loaded with residue; as a result, some lots of apples may carry more residue after dry brushing than before. This method cannot be recommended for the removal of spray residues.

TABLE 1. AMOUNTS OF LEAD AND ARSENIC REMOVED FROM APPLES BY DRY BRUSHING

Grain per pound	Before brushing	After brushing
Pb	.024	.027
	.009	.013
	.014	.008
As_2O_3	.007	.006
	.004	.005
	.006	.003

Hand Dipping.—For small quantities of apples, hand dipping of fruit in picking crates or other slatted containers has been suggested. The apples are dipped into a tank containing the wash solution and allowed to remain there for the required time, usually from one to two minutes. They are then lifted out and rinsed thoroughly in a tank of clean water. This method is fairly satisfactory for a few hundred bushels, but the labor cost is high, and the splashing of the wash solution, which usually is corrosive, makes this method impractical for a crop much larger than 1,000 bushels.

Washers

Various washing machines have been devised. All operate on the same general principle; the apples are carried along by some mechanical means, and subjected first to the wash solution for the required length of time, and then to a rinse solution.

Flotation Washers.—These are the simplest type from the mechanical point of view. They consist of rotating paddles or conveyor slats which push the apples along as they float through the washing solution and the rinse water. Although not quite so efficient as washers having a scrubbing action, flotation washers have the advantage of low cost and may be constructed by anyone possessing some mechanical ability.

Residue removal by a flotation washer with cold acid wash solution is satisfactory when the residue is not too great and is not complicated by heavy applications of mineral oil. Table 2 gives typical results secured with a home-made flotation washer on different varieties of fruit, with two levels of acid concentration.

The residue levels found were not always in proportion to the number of cover sprays applied. This indicates variations in thoroughness of application in different orchards. The effect of adding skim milk to the

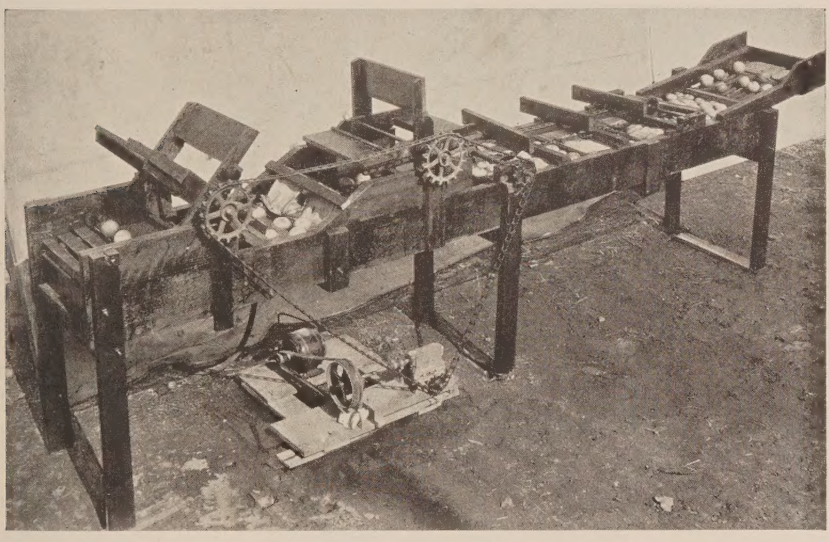

FIG. 1. SMALL, HOME-MADE FLOTATION TYPE FRUIT WASHER (SEE FIG. 2) WITH CAPACITY OF 1000 BUSHELS A DAY

spray mixture is shown in Tables 2 and 6. The larger apples retain less residue at harvest, when this is figured as grains per pound of fruit. For example, a sample of York Imperial was separated on the basis of diameter into three sizes: 2 to 2½ inches, 2½ to 3 inches, and 3 inches up. For these three sizes, the lead residues were respectively, .030, .024, and .022 grain per pound, and the arsenic trioxide .013, .012, and .010 grain

TABLE 2. TYPICAL RESULTS OF RESIDUE REMOVAL FROM APPLES, GRAIN PER POUND, 1 MINUTE EXPOSURE—FLOTATION WASHER

Sample No.	Variety	Number cover sprays	Before washing		Residue after washing in 0.5% HCl		1.0% HCl		2.0% HCl	
			Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3
A-1	Red Bird	4	.034	.008	.005	.001				
A-4	E. Harvest	4	.030	.011	.006	.002				
A-76	Smokehouse	4	.056	.026			.016	.007		
A-32	Delicious	6*	.048	.014	.020	.010	.018	.008	.011	.005
A-87	Stark	5	.026	.015			.011	.005		
A-24	Jonathan	3	.033	.008	.012	.005				
A-83	Jonathan	7*	.050	.025	.026	.011	.018	.009		
A-123	Grimes	6	.032	.016			.010	.002		
A-127	Grimes	6*	.067	.022			.025	.008	.015	.002
A-218	Stayman	4	.054	.010			.012	.007		
A-369	Stayman	6*	.075	.022			.018	.004	.010	.003
A-166	York	4	.025	.007			.017	.006		
A-368	York	6*	.054	.022			.016	.006	.012	.004
A-216	Rome	4	.054	.017			.014	.006		
A-211	Rome	6*	.067	.027			.020	.011	.015	.010

* Skimmed milk added.

per pound. In addition, apples on the lower branches invariably retain more residue than those in the upper parts of the tree.

A detailed description of a satisfactory home-made flotation washer, with scale drawings, is given on pages 11 to 13. The experimental results reported in Table 2 were secured with this type of washer.

Flood or Spray Washers.—In this type, the apples are pushed forward by a continuous series of paddles on an endless chain, or other similar means, and are subjected to a heavy spray or flood of washing solution, followed by rinse water. These washers were popular in the early days of residue removal, but apparently are not used much at present. They have one advantage over the flotation washer, in that the fruit is washed with a solution which circulates continuously, but the increased cost of construction more than offsets this advantage.

TABLE 3. COMPARISON OF SPRAY RESIDUE REMOVAL BY FLOTATION WASHER AND BRUSH WASHER AT ROOM TEMPERATURE

Variety	Lead Grain per pound			Arsenic (As_2O_3) Grain per pound		
	Before washing	After flotation washer	After brush washer	Before washing	After flotation washer	After brush washer
1% Hydrochloric acid						
York	.044	.016	.014	.015	.004	.003
	.054	.016	.018	.022	.006	.006
Stayman	.049	.016	.015	.015	.003	.005
	.075	.018	.012	.022	.004	.004
2% Hydrochloric acid						
York	.044	.020	.016	.015	.006	.033
	.054	.012	.019	.022	.004	.003
Stayman	.049	.016	.011	.015	.004	.002
	.075	.010	.018	.022	.003	.003

Brush Washers.—These are equipped with rotary brushes of fiber, rubber, or other material, over which the apples pass in their progress through the machine, while the wash solution is forced over them. The fruit thus is subjected to a mechanical scrubbing action, as well as to a flood of wash solution. This combined mechanical and chemical action is, on the average, a more efficient means of removing residues than any of the methods previously described, as is shown in Table 3. The brush machine did not always remove more lead and arsenic than the flotation machine, but this was true in most cases. Because of their complex mechanism, brush washers are considerably more expensive than flotation washers.

Driers

Driers have been designed to remove the water adhering to the fruit after washing. There are two general types: the roller and the belt type, both of which remove water by means of absorbent cloths which are wrung out mechanically. These are fairly efficient but do not remove water from the stem and calyx ends of the fruit, so that the apples are still damp after

drying. The presence of moisture on the fruit when packed does not affect its keeping quality. The main advantage of drying is that fruit with the excess water removed is considerably easier to handle, especially in cold weather.

TABLE 4. COMPARISONS OF UNHEATED WASH SOLUTIONS CONTAINING SODIUM SILICATE AND HYDROCHLORIC ACID, GRAIN PER POUND

Sample No.	Variety	Before washing		After washing with			
				80 lbs.—100 gal. BW Silicate		HCl—1%	
		Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3
A–121	Hubbardston *	.084	.038	.074	.034	.042	.021
A–126	Grimes †	.084	.038	.046	.015	.033	.008
A–35	Jonathan *	.140	.024	.076	.020	.033	.013
A–210	Rome	.054	.024	.042	.016	.027	.013
A–243	York	.140	.083	.056	.027	.036	.025
A–245	Stayman	.071	.046	.026	.009	.012	.010

* Skimmed milk added
† Fish oil added

Wash Solutions

Alkaline Wash Solutions.—In the apple growing sections of the Pacific Northwest, where mineral oil sprays are applied frequently in summer, alkaline washes of sodium silicate or sodium carbonate have been used. These are less efficient than hydrochloric acid solutions under Pennsylvania conditions. Oil sprays may make alkaline washes necessary in Pennsylvania in the future, but under present conditions, in which the grower uses casein spreaders or fish oil, dilute hydrochloric acid is superior. Table 4 shows the amounts of lead and arsenic removed by solutions of sodium silicate as compared with hydrochloric acid wash solutions.

Acid Wash Solutions.—Dilute solutions of hydrochloric acid are the most efficient wash solutions under Pennsylvania conditions. The greater the strength of the acid, the more residue is removed (Table 2), but when concentrations above 2 per cent by weight are used there is danger of injuring the fruit. For most varieties, a solution containing 1.5 per cent by weight probably is most satisfactory.

Making and Testing Acid Solution

Commercial hydrochloric (muriatic) acid of 20° Baume strength, in carboys, is the cheapest way to buy the acid. The carboys hold 125 pounds, or approximately 12 gallons of acid, containing about 31.5 per cent by weight of the pure acid. To make a wash solution containing one per cent of the acid by weight, approximately 26 pounds of the commercial 20° Baume acid should be used per 100 gallons of water, or about 3 gallons of acid per 100 gallons of water. For a 1.5 per cent acid solution, 4.5 gallons should be used per 100 gallons of water. Table 5 shows the

number of gallons of commercial acid required to make wash solutions of various strengths.

The concentrated acid is very corrosive and should not come in contact with the skin or clothing. It is wise to have a bag of hydrated lime at hand to neutralize any spilled acid. The acid should be measured out in glass or sound porcelain utensils.

TABLE 5. DILUTION TABLE FOR ACID SOLUTIONS

Desired concentration	Gallons of commercial HCl to add to		
% Acid	50 gal. tank	100 gal. tank	200 gal. tank
0.5	0.75	1.5	3.0
1.0	1.50	3.0	6.0
1.5	2.25	4.5	9.0
2.0	3.00	6.0	12.0

Testing.—After an acid solution has been used in the washer for some time it gradually loses strength. This is due to neutralization of the acid by the spray residues, and to dilution resulting from moisture on the fruit. Some of the acid solution usually is carried over on the surface of the apples into the rinse tank, thus resulting in a further lowering of the acid content. In order to add the required amount of water and acid, the strength of the acid must be determined. The test requires a 10 cc. transfer pipette, a 10 cc. graduated pipette, two glass tumblers, and a standard alkali solution and indicator. Standard alkali solution may be obtained from any large drug store; it should contain 23 grams of sodium bicarbonate to 1000 cc. of water, with sufficient methyl orange added to give a yellow color. The pipettes may be secured from any chemical supply company.[2]

The following procedure is used to determine the strength of the washing solution:—

Remove a glassful of the solution from the washer, making sure that it is well mixed. Draw the solution into the 10 cc. bulb pipette by suction until the level is above the mark on the tube above the bulb. Allow the solution to run out slowly until it is even with the mark; the pipette then contains exactly 10 cc. of the solution. Allow all of this to drain into the other clean tumbler; then, with the graduated pipette, measure the alkali solution to the upper graduation (0.0 cc. mark). Add the alkali solution in the graduated pipette slowly, with stirring, to the acid solution in the tumbler, stopping when the liquid in the tumbler changes color. Note the number of cc.'s of alkali solution used. This, divided by 10, gives the percentage of acid in the wash solution.

[2] While the solution mentioned above may be used for testing the acid strength, it is not satisfactory in all respects, and often cannot be obtained locally. A more satisfactory standard alkali solution made with sodium hydroxide to the same strength may be purchased from Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa., or LaMotte Chemical Products Co., Baltimore, Md. Both firms sell a complete outfit for testing washing acid solutions, including pipettes, tumblers, alkali solution, and indicator.

For example, if the solution required 8 cc. of alkali solution to neutralize it, this would indicate an acid strength of 0.8 per cent hydrochloric acid by weight. To make 100 gallons of this solution up to 1.0 per cent by weight it would be necessary to add 0.2 (1.0–0.8) x 3 gallons, or approximately 0.6 gallons of concentrated acid.

Care should be taken that all glassware is clean.

When a washer of standard size is used, the acid solution should be changed after washing approximately 1,000 bushels of apples. This represents an average day's run; it usually is most convenient to drain the washer in the evening and to make up a new solution each morning.

Heating the Solution.—It has been recommended that the acid solution be heated to between 90° and 100° F. when residues are difficult to remove. Table 6 indicates that heating the wash solution to 100° F. increased the efficiency greatly. Heating is recommended where residues are present which are not satisfactorily reduced with cold acid.

TABLE 6. INCREASE IN EFFICIENCY OF SPRAY RESIDUE REMOVAL WHEN WASH SOLUTIONS ARE HEATED

Variety	Original load	After 1% acid 60° F.	After 1% acid 100° F.	After 2% acid 60° F.	After 2% acid 100° F.
	Lead (grain per pound)				
York	.052	.018	.014	.016	.015
Stayman	.069	.017	.015	.016	.014
	Arsenic (grain per pound)				
York	.019	.006	.003	.005	.003
Stayman	.019	.005	.005	.004	.003

Heating may be accomplished in several ways. Where electricity is available, a 5 or 10 kilowatt immersion heater has been satisfactory, although the expense of operation is rather high. Live steam from a boiler or steam coils also appears to be satisfactory. Circulation of the acid solution directly through a heater leads to rapid corrosion and is not recommended unless acid-resisting metal is available.

TABLE 7. COMPARISON OF ACID WASH SOLUTIONS WITH AND WITHOUT WETTING AGENTS, 1 MINUTE EXPOSURE, FLOTATION WASHER

Sample No.	Variety	Grain per pound							
		Before washing		2% HCl		2% HCl plus wetting agent ‡		2% HCl plus wetting agent §	
		Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3
A-367	Stayman	.049	.015	.016	.004	.009	.001	----	----
A-369	Stayman*	.075	.022	.010	.003	.016	.003	----	----
A-370	Stayman†	.082	.017	.020	.005	.016	.004	----	----
A-366	York	.044	.015	.020	.006	----	.002	----	----
A-368	York*	.054	.022	.012	.004	.011	.001	----	----
A-370	York†	.060	.020	.020	.006	.015	.004	----	----
A-74	Jonathan*	.088	.043	.023	.008	.024	.011	.022	.009
A-125	Grimes†	.084	.032	.024	.011	.024	.010	.025	.011
A-165	Stayman*	.038	.013	.008	.003	.009	.006	.008	.004

* Plus skimmed milk, 2 lbs.—100 gal.
† Plus fish oil, 2 qts.—100 gal.
‡ Vatsol, 8 lbs.—100 gal. + De Gras, 1 qt.—100 gal.
§ Areskap, 1 gal.—100 gal.

Wetting Agents.—These lower the surface tension of the wash solution and allow the waxy surface of the apple to be wet completely. Theoretically, they should allow a more complete removal of spray residues. Several of these materials were tested on Pennsylvania fruit in 1935. Representative results are given in Table 7. In general, no more residue was removed when the wetting agents were added than when acid alone was used. Wetting agents may have a place, however, in washing apples that have been sprayed heavily with mineral oil-lead arsenate sprays.

Salt.—The addition of common salt to acid wash solutions has appeared, in some other sections, to facilitate residue removal. Tests with Pennsylvania apples in 1934 (Table 8) indicated that, while salt may have increased the removal of arsenic in most instances, it interfered with the removal of lead.

TABLE 8. THE EFFECT OF ADDING SALT TO WASH SOLUTIONS OF HCl, 1 MINUTE EXPOSURE, FLOTATION WASHER

Sample No.	Variety	Grain per pound							
		Before washing		1% HCl		1% HCl plus 1% salt		1% HCl plus 10% salt	
		Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3	Pb	As_2O_3
A-25	Smokehouse	.070	.017	.020	.008	.019	.007	----	----
A-35	Jonathan	.140	.024	.033	.013	.034	.013	.037	.007
A-126	Grimes	.084	.038	.033	.008	----	----	.048	.011
A-243	York	.140	.083	.036	.025	----	----	.040	.016
A-245	Stayman	.071	.046	.012	.010	----	----	.014	.036

Rinsing

Rinsing the fruit is very important in any type of washer. Fruit improperly rinsed will tend to develop injury in storage, because of the action of the acid on the lead arsenate remaining on the surface of the apples; this sets free soluble arsenic and results in arsenical injury, particularly around the calyx end of the fruit. The amount of rinse water used should be as large as is economical; at least 2 to 3 gallons of fresh water should be used for each bushel of apples washed. A satisfactory qualitative test for thoroughness in rinsing is to touch the tip of the tongue to the calyx opening of the fruit as it comes from the washer. If rinsing is not complete the sour taste of the acid is noticeable.

Factors Influencing the Effectiveness of Residue Removal

Spray Applications.—The common spray treatments in Pennsylvania appear to offer no great difficulty to the removal of the residue, if late applications in excess of the spraying recommendations are avoided. Lead arsenate-lime sulphur alone, or used with casein or skim milk spreaders, left a residue which was not difficult to remove if present in amounts less than approximately twice the tolerance (0.040 grain of lead per pound; 0.020 grain of arsenic per pound). Sprays containing fish oil left a residue more difficult to remove. Sprays containing lead arsenate and mineral oil have not been used enough in Pennsylvania to make any conclusion

possible, although experiments in other states have indicated that the residues produced by such sprays are extremely difficult to remove; hence oil sprays should be avoided so far as possible.

Variety.—The varieties of apples used in this investigation showed considerable difference in ease of washing. Stayman and Smokehouse cleaned most readily, followed by Grimes, Rome, Jonathan, York, Stark, Yellow Newtown, and Hubbardston. The order of these varieties is tentative, some of them being represented by too few samples to permit a definite statement. Hubbardston was particularly difficult to clean. Any variety of apples may be cleaned much more readily directly after picking than later. The production of wax on the surface of the apple, which occurs when fruit is held in storage, makes the removal of spray residues more difficult.

Effect on Keeping Qualities.—Washing with dilute solutions of hydrochloric acid at concentrations of 2 per cent or less apparently did not impair the keeping qualities of marketable apples, when properly rinsed. Packing the apples when wet did not affect their keeping qualities in storage. Cull apples, however, in which there were a number of cut and bruised fruits, did not keep well after washing, apparently because of the entrance of the acid into the flesh of the fruit. The solution apparently was very difficult to remove by rinsing and exerted a harmful effect later.

SMALL HOME-MADE FLOTATION WASHER

A. W. Clyde

Fig. 2 shows a small washer in which the time in the acid tank is controlled by the speed of the machine rather than by the rate of feeding as in some home-made washers. It has a capacity of about 60 bushels per hour when apples are kept one minute in the acid tank. Apples are fed in at the right end and are carried along by the conveyor until they reach the first paddle elevator. They are then lifted out of the acid and dropped into the rinse tank. As the second paddle elevator lifts them out of the water, they are sprayed with fresh water, at least two gallons of water per bushel being advisable.

If greater capacity is desired, it will be more economical, within reasonable limits, to increase the width rather than the length. It is recommended that two chains be provided for the acid tank conveyor if the width is more than 20 inches.

Lumber one and one-half inches thick is adequate for the tank. Tongued and grooved stock is preferred. Plain edged lumber can be made watertight, however, by careful fitting of the edges and by using an asphalt roofing cement or putty. The acid solution will corrode iron or steel; hence it is good practice to countersink bolts, screws, and nails and cover them with asphalt putty. Asphalt paint should be used for the entire tank, as ordinary paints will not stand the acid.

To prevent apples being caught between the paddle elevators and the inclines, it is important that the tanks be filled to within about one inch of the top when operating. This puts the paddles about three inches deep

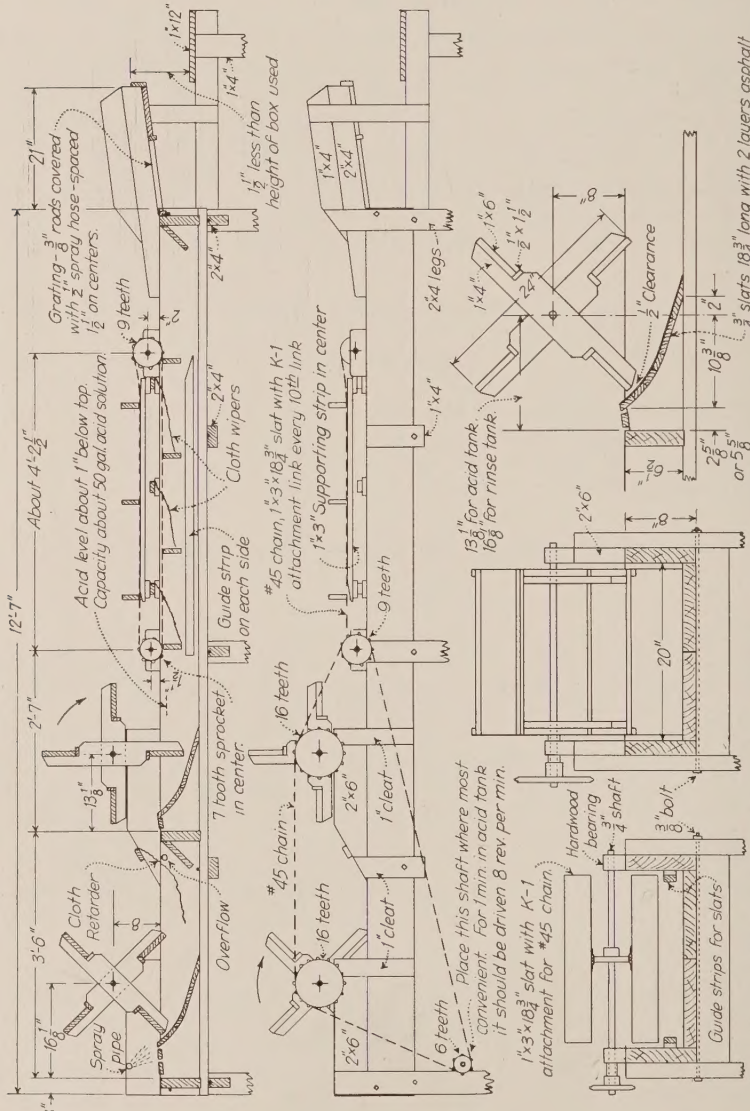

FIG. 2. DESIGN OF FRUIT WASHER SHOWN IN FIG. 1

in the liquid at their lowest position. The cloth retarder in the rinse tank prevents bruising of apples as they drop into the tank. It is made of toweling or other heavy cloth and should be adjusted to let the apples slide gently into the tank.

The fresh water spray may be made by drilling holes in a pipe, but a few spray nozzles will be more effective.

The most practical method for getting the required speed must be worked out for each installation. As noted on the drawing, the countershaft should be driven 8 r.p.m. for 1 minute in the acid tank. With the speed and sprockets specified, the paddle elevators will run at 3 r.p.m. Apples are likely to be caught between the paddles and the inclines if the elevators run much faster than this. In many cases, power can be taken from a comparatively slow speed shaft on the apple grader in order to simplify the reduction to the slow speed required. If an electric motor is provided for the washer probably it will be best to get a worm reducing gear to give considerable of the speed reduction. The power needed is less than one-fourth horsepower. Suggestions for getting proper speed of the washer will be supplied by the Department of Agricultural Engineering, The Pennsylvania State College, State College, Pa., if information is given as to the speed of the shaft from which power will be taken.